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2. "Researches in the Theory of Machines." By the Rev. H. Moseley, M.A., F.R.S., Professor of Natural Philosophy and Astronomy in King's College, London.

Of the various names, such as "useful effect," "dynamical effect," "efficiency," "work done," "labouring force," "work," which have been given to that operation of force in machinery which consists in the union of a continued pressure with a continued motion, the author gives the preference to the term *work*, as being that which conveys, under its most intelligible form, this idea of the operation of force, and as being the literal translation of the word "travail," which among French writers on mechanics has taken the place of every other.

The single unit, in terms of which this operation of force is with us measured, viz. the work of overcoming a pressure of one pound through one foot, he considers to be distinguished sufficiently, and expressed concisely enough, by the term *unit of work*, rejecting as unnecessary, and as less likely to pass into general use, the terms "dynamical unit," and "dynam," which it has been proposed to apply to it.

Having thus defined the terms *work* and *unit of work*, and paid a tribute of respect to the valuable labours of M. Poncelet in the theory of machines, and expressed admiration of the skill with which he has applied to it the well-known principle of *vis viva* under a new and more general form, the author proceeds to remark, that the interpretation which M. Poncelet has given to that function of the velocity of a moving body which is taken as the measure of its vis viva, associates with it the definitive idea of a force opposed to all change in the state of the bodies' rest or motion, and known as its "*vis inertiæ*," "*vis insita*," &c. The author conceives that the introduction of the definitive idea of such a force into questions of elementary and practical mechanics is liable to many and grave objections; and he proposes a new interpretation of it, viz. "that one half of this function represents the number of units of work accumulated in the moving body, and which it is capable of reproducing upon any resistance opposed to its progress." This interpretation he establishes by mechanical considerations of an elementary kind. Taking, then, this new interpretation of the function representing one half the vis viva, and dividing the parts of a machine into those which receive the operation of the moving power (the moving points) and those which apply it (the working points), he presents the principle of vis viva in its application to machines under the following form:—"The number of units of work done by the moving power upon the moving points of the machine is equal to the number yielded at the working points, *plus* the number expended upon the prejudicial resistances, *plus* the number accumulated in the various parts of the machine which are in motion." So that the whole number of units of work done by the moving power, or upon the moving points, is expended, partly in that work done at the working points, whence results immediately the useful product of the machine, and partly upon the prejudicial resistances of friction, &c. opposed to the motion of the machine in

its transmission from the moving to the working points; and all the rest is accumulated or treasured up in the moving parts of the machine, and is reproducible whenever the work of the moving power from exceeding shall fall short of that which must be expended upon the useful and the prejudicial resistances to carry on the machine.

He then proceeds to observe, that in every machine there thus exists a direct relation between these four elements,—the work done upon the moving points, that expended at the working points, that expended on the prejudicial resistances, and that accumulated in the moving elements. This relation, which is always the same for the same machine, and different for different machines, he proposes to call, in respect to each particular machine, its *modulus*; and he states the principal object of this paper (and of another which he proposes subsequently to submit to the Society) to be, first, the general determination of the modulus of a simple machine; secondly, that of a compound machine, from a knowledge of the moduli of its component elements; and, thirdly, the application of these general methods of determination to some of the principal elements of machinery, and to the machines which are in common use.

The author then states, that the velocities of the different parts, or elements of every machine are connected with one another by certain invariable relations, capable of being expressed by mathematical formulæ; so that, though these relations are different for different machines, they are the same for the same machine. Thus it becomes possible to express the velocity of any element of a machine, at any period of its motion, in terms of the corresponding velocity of any other element. Whence it results that the whole vis viva of the machine may at any time be expressed in terms of the corresponding velocity of its moving point (that is, the point where the moving power is applied to it), and made to present itself under the form $V^2 \Sigma \omega \lambda^2$, where V represents the velocity of the moving point of the machine, ω the weight of any element, and λ a factor determining the velocity of that element in terms of the velocity V of the moving point. Substituting this expression for the vis viva or accumulated work in the modulus and solving in respect to V, an expression is obtained, whence it becomes apparent that the variation of the velocity V of the moving point, produced by any given irregularity in the work done upon the moving or working points, will be less, as the factor $\Sigma \omega \lambda^2$ is greater. This factor, determinable in every machine, and upon which the uniformity of its action under given variations of the power which impels it depends, he proposes to introduce into the general discussion of the theory of machines as the *coefficient of equable motion.*

He then proceeds to investigate general methods for the determination of the modulus of a machine, deducing them from those general relations which are established by the principles of statics, between the pressures applied to the machine, in its state bordering upon motion.

That he may escape that complication of formulæ which results from the introduction of friction, by the ordinary methods, into the

consideration of questions of equilibrium, the author calls to his aid a principle, first published by himself in a paper on the 'Theory of the Equilibrium of Bodies in contact,' printed in the fifth volume of the Cambridge Philosophical Transactions, viz. "that when the surfaces of two bodies are in contact under any given pressures, and are in the state bordering upon motion, on those surfaces, then the common direction of the mutual resistances of the surfaces is inclined to their normal at the point of contact at a certain angle, given in terms of the friction of the surfaces by the condition that its tangent is equal to the coefficient of friction." This angle the author has called "*the limiting angle of resistance*:" it has since been used by other writers under the designation of the "*slipping angle*."

He next proceeds to determine the modulus of a simple machine, moveable about a cylindrical axis of given dimensions, and acted upon by any number of pressures in the same plane. He applies the principle last stated to determine the general conditions of the equilibrium of these pressures, in the state bordering upon motion by the preponderance of one of them; and, solving the resulting equation in respect to that one pressure by the aid of Lagrange's theorem, he deduces immediately the modulus from this solution by principles before laid down. The modulus, thus determined, he then verifies by an independent discussion of that particular case in which three pressures only are applied to the machine, one of which has its direction through the centre of the axis.

This solution he next considers more particularly with reference to a machine moveable about a fixed axis under one moving and one working pressure (their directions being any whatever) and its own weight; which last is supposed to act through the centre of the axis. He shows that it is a general condition of the greatest economy in the working of such a machine, that the moving and working pressures should have their directions, one of them upwards, and the other downwards, and that both should therefore be applied on the same side of the axis of the machine. He moreover shows that if the direction of one of these pressures be given, there is then a certain perpendicular distance of the other from the centre of the axis, and a certain inclination of its direction to the vertical, at which perpendicular distance, and which inclination, this pressure being applied, the machine will yield a greater amount of work, by the expenditure of a given amount of power, than it will yield under any other circumstances of its application: so that this particular distance and inclination are those whence results the most economical working of the machine.

Professor Moseley then commences his application of these general principles to elementary machines with the pulley. He establishes the modulus of the pulley under any given inclination of the parts of the cord passing over it, taking into account the friction of the axis, the weight of the pulley and the rigidity of the cord, and adopting, with respect to the last element, the experiments of Coulomb. This general form of the modulus of the pulley he applies, first, to the case in which both strings are parallel, and inclined to the vertical

at any angle; secondly, to the case in which they are equally inclined on either side of the vertical; thirdly, to the case in which one is horizontal and the other vertical; and, fourthly, to that in which both are horizontal. He concludes his paper by a deduction from this last case of the modulus of a system of any number of pulleys or sheaves, sustaining among them the weight of any given length of rope horizontally.

3. "On the Nervous Ganglia of the Uterus." By Robert Lee, M.D., F.R.S.

The author, in a paper which was read to the Royal Society on the 12th of December, 1839, had described four great plexuses under the peritoneum of the gravid uterus, having an extensive connexion with the hypogastric and spermatic nerves. From their form, colour, general distribution, and resemblance to ganglionic plexuses of nerves, and from their branches actually coalescing with those of the hypogastric and spermatic nerves, he was induced to believe, on first discovering them, that they were ganglionic nervous plexuses, and that they constituted the special nervous system of the uterus. He states in the present paper, that subsequent dissections of the unimpregnated uterus, and of the gravid uterus in the third, fourth, sixth, seventh, and ninth months of pregnancy, have enabled him not only to confirm the accuracy of his former observations, but also to discover the important fact, that there are many large ganglia on the uterine nerves, and on those of the vagina and bladder, which enlarge with the coats, blood-vessels, nerves, and absorbents of the uterus during pregnancy, and which return, after parturition, to their original condition before conception took place. The author next proceeds to describe the two great ganglia situated on the sides of the neck of the uterus, in which the hypogastric and several of the sacral nerves terminate, and which he calls the *hypogastric*, or *utero-cervical ganglia*. In the unimpregnated state, they are of an irregular, triangular, or oblong shape, about half an inch in the long diameter, and always consist of grey and white matter, like other ganglia. They are covered by the trunks of the vaginal and vesical arteries and veins; and each ganglion has an artery of considerable size, which enters it near the centre and divides into branches, accompanying the nerves given off from its anterior and inferior borders. From the inner and posterior surface of each of these ganglia, nerves pass off, which anastomose with the hæmorrhoidal nerves, and ramify on the sides of the vagina, and between the vagina and rectum. From the inferior border of each hypogastric ganglion several fasciculi of nerves are given off, which pass down on the sides of the vagina, and enter some large flat ganglia, midway between the os uteri and ostium vaginæ. From these vaginal ganglia innumerable filaments of nerves, on which small flat ganglia are formed, extend to the sphincter, where they are lost in a white dense membranous expansion. From this great web of ganglia and nerves numerous branches are sent to the sides of the bladder, and enter it around the ureter. All these nerves of the vagina are accompanied with arte-